



**UNIVERSITI PUTRA MALAYSIA**

**DEVELOPMENT OF AN EXPERT SYSTEM FOR ENVIRONMENTAL  
MANAGEMENT PLANNING: SOIL AND WATER CONSERVATION**

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**DEVELOPMENT OF AN EXPERT SYSTEM FOR ENVIRONMENTAL  
MANAGEMENT PLANNING: SOIL AND WATER CONSERVATION**

**By**

**SUTTIPONG PRUANGKA**

**Thesis Submitted in Fulfilment of the Requirement for the  
Degree of Doctor of Philosophy in the Faculty of Engineering  
Universiti Putra Malaysia**

**December 2000**



**This thesis is dedicated to the author's beloved mother, Thongjua Pattatesang  
and the stepfather, Somchai Pattatesang, who is always the gentleman  
in the author's mind**

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment  
of the requirement for the degree of Doctor of Philosophy

**DEVELOPMENT OF AN EXPERT SYSTEM FOR ENVIRONMENTAL  
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**December 2000**

**Chairman: Associate Professor Mohamed Daud, Ph.D., P.Eng., MBA**

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A computer-based expert system, EMP-Ex, has been developed for environmental management planning with regard to soil and water conservation, particularly during earthwork activities of development projects. It is a rule based expert system programmed in wxCLIPS 1.62. The EMP-Ex is able to predict soil erosion rate and peak runoff caused by development activities and then recommends suitable strategies for conserving soil and water resources, monitoring the effectiveness of mitigation measures and water quality. The system provides users a checklist of required items and suggestions for steps to be taken in the preparation of Environmental Management Plan (EMP) including planning for emergencies and in the production of an EMP report. The system's knowledge base comprises descriptive and prescriptive knowledge elicited from domain experts and additional supporting information acquired from literature. The domain knowledge was incorporated into the system in the form of production rules that can be updated and referred to through the system. EMP-Ex has been verified and validated to evaluate system capabilities by wxCLIPS facilities, face validation, Turing test, and field study. The results show that EMP-Ex is able to function as good as human experts

with a ninety-five percent of confidence level. Through interfacing with other external programmes (e.g. AutoCAD, IDRISI, Microsoft Office, Netscape Navigator etc.), the system extends its capability in sharing and storing raw knowledge and external databases for further reference or updating and provides users the convenience in using additional facilities of the external programmes interfaced. By automating EMP processes, not only can EMP-Ex help EMP planners to improve the quality and the quantity of work, but it can also assist the authorised agencies such as the Department of Environment (DOE) in auditing and revising the plans, especially in the situation of insufficient human experts.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PEMBANGUNAN SISTEM PAKAR UNTUK PERANCANGAN  
DAN PENGURUSAN ALAM SEKITAR: PEMULIHARAAN SUMBER  
TANAH DAN AIR**

**Oleh**

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Sistem pakar EMP telah dibangunkan melalui program wxCLIPS 1.62 untuk tujuan perancangan dan pengurusan alam sekitar. EMP-Ex berupaya meramalkan tahap hakisan tanah dan aliran air puncak yang akan berlaku akibat aktiviti pembangunan. Selain ramalan, sistem ini juga menawarkan cadangan seperti langkah-langkah pencegahan, environmental monitoring, pemuliharaan sumber tanah dan air untuk mengelakkan atau merendahkan kesan-kesan buruk. Sistem ini juga memberi senarai penyemakan dan cadangan kepada pengguna di dalam langkah-langkah penyediaan Environmental Management Plan (EMP), termasuklah perancangan untuk kejadian kecemasan. Di samping itu, satu laporan EMP akan dihasilkan untuk pengguna. Dasar pengetahuan sistem dibangunkan berdasarkan maklumat yang diperolehi daripada pakar-pakar di dalam bidang berkaitan serta bahan bahan rujukan yang terdapat. Dasar pengetahuan tersebut bukan sahaja menawarkan perujukan maklumat malahan membenarkan pembaharuan maklumat dilakukan demi bersesuaian dengan keadaan semasa. Kebolehan EMP-Ex telah diuji dan disahkan melalui kemudahan wxCLIPS, face validation, turing test dan kajian di tempat sebenar. Pengujian telah memberi keputusan bahawa kebolehan EMP-Ex

adalah setanding dengan pakar-pakar manusia dan mempunyai tahap kepercayaan sebanyak sembilan puluh lima peratus. Pelingkaran kepada perisian-perisian seperti AutoCAD, IDRISI, Microsoft Office, Netscape Navigator dan sebagainya telah melanjutkan kebolehan sistem ini serta memberi kemudahan kepada pengguna. Kesimpulanya, EMP-Ex dapat membantu perancang EMP atau pihak berkaitan seperti Jabatan Alam Sekitar (DOE) dalam meninggikan kualiti perancangan dan pembuatan keputusan, terutama pada keadaan kehausan tenaga pakar ini.

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I certify that an Examination Committee met on 22<sup>th</sup> December 2000 to conduct the final examination of Suttipong Pruangka on his Doctor of Philosophy thesis entitled “Development of an Expert System for Environmental Management Planning: Soil and Water Conservation” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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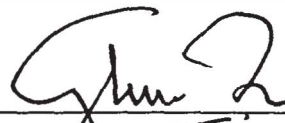
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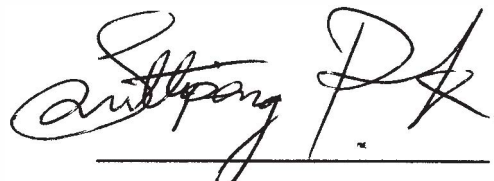


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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.



SUTTIPONG PRUANGKA

Date: January 4, 2001

## TABLE OF CONTENTS

	<b>Page</b>
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL SHEETS	ix
DECLARATION FORM	xi
LIST OF TABLES	xiv
LIST OF FIGURES	xvi
LIST OF ABBREVIATIONS	xix
 <b>CHAPTER</b>	
 I INTRODUCTION	 1
Statement of the Problem	2
Research Objectives	3
Scope and Limitations	4
Expected Outcome of the Study	4
 II LITERATURE REVIEW	 5
Environmental Impact Assessment	5
Environmental Management Plan	8
Environmental Monitoring and Auditing	10
Soil Erosion and Runoff Prediction	11
Expert Systems in Environmental Management	27
CLIPS, as an Expert System Development Tool	38
 III METHODOLOGY	 43
Phase 1 Identification	44
Phase 2 Knowledge Acquisition	47
Phase 3 System Design	54
Phase 4 System Testing	54
Phase 5 System Maintenance	54
Environmental Management Plan Generation	55
 IV RESULTS AND DISCUSSION	 56
Knowledge Acquisition	56
System Design	107
System Operation and Description	130
System Testing	172
System Maintenance and Documentation	204
 V CONCLUSION	 214
Contribution of the Study	217
Recommendation for Future Research	221

	<b>Page</b>
REFERENCES	222
APPENDIX	
A    EMP-Ex Source Code	230
B    EMP-Ex User Guide	292
C    Questionnaire for Face Validation	294
D    EMP Report Produced by EMP-Ex	295
VITA	316

## LIST OF TABLES

Table	Page
1 Institutions contacted and information gathered	48
2 Preliminary knowledge derived from EIA reports	59
3 Summary of methods used to evaluate rainfall erosivity factor in EIA reports	61
4 Annual rainfall and rainfall erosivity index for all states of Malaysia used to develop EMP-Ex	63
5 Frequency of methods used to evaluate soil erodibility factor in EIA	64
6 Recommended soil erodibility factor if the details of textural classification are available	66
7 Recommended soil erodibility factor if the details of textural classification are unavailable	67
8 Frequency of methods used to evaluate LS factor in EIA	68
9 Class intervals and median values assigned for LS factor	70
10 Knowledge elicited from domain experts regarding cover factor C	72
11 Knowledge elicited from domain experts regarding erosion control practice factor P	72
12 Elicited knowledge of supporting conservation practice factor values for different land uses	73
13 Runoff coefficient based on the percentage of disturbed area	78
14 Example of static databases showing the relationship of location and rainfall intensity under different return periods for the time of concentration 15 minutes	84
15 Generic guidelines for soil and water conservation	86
16 Specific guidelines for soil and water conservation	87
17 Considerable choice selection of mitigation measures	89
18 Sources of files containing knowledge bases of monitoring and maintaining the effectiveness of mitigation measures	90

<b>Table</b>	<b>Page</b>
19 Extracted knowledge in monitoring and maintaining erosion and sedimentation control measures	92
20 Recommended water quality criteria and frequency of monitoring	97
21 Steps to prepare an EMP for soil and water conservation	99
22 Checklist of items for the preparation of Environmental Management Plan in soil and water conservation	104
23 List of questions, answers, purposes of asking the questions, and EMP-Ex production rules in soil erosion prediction	139
24 List of questions, answers, purposes and EMP-Ex production rules in runoff prediction for projects located in urban areas	146
25 List of questions, answers, purposes and EMP-Ex production rules in runoff prediction for projects located in rural areas	152
26 Evaluator's acceptance from face validation	183
27 Results of Turing test applied in EMP-Ex testing	189
28 Results of Chi-square test for the Turing test of EMP-Ex	194
29 Questions and selected answers for soil erosion prediction by EMP-Ex using field study of a road construction project entitled "Project Jalan Raya Pos Selim, Perak ke Ladang Blue Valley, Pahang"	197
30 Comparison of soil erosion prediction between field studies and EMP-Ex knowledge bases	198
31 Questions and selected answers for peak runoff prediction by EMP-Ex using field study of a road construction project entitled "Project Jalan Raya Pos Selim, Perak ke Ladang Blue Valley, Pahang"	199
32 Comparison of peak runoff prediction between field studies and EMP-Ex knowledge bases	200



## LIST OF FIGURES

Figure	Page
1 Structure of expert system	32
2 Flow diagram of EMP-Ex development	43
3 Cycle of knowledge acquisition procedure in EMP-Ex	53
4 An example of extracted knowledge in monitoring and maintaining vegetation	91
5 Table of contents of general EMP	100
6 Extracted knowledge for writing an EMP report	101
7 Results of extracted knowledge in planning for emergencies	102
8 The operational structure of EMP-Ex knowledge mode	109
9 The first screen of EMP-Ex	110
10 Organisation of 'File module'	111
11 Organisation of 'Introduction module'	112
12 Organisation of 'EIA module'	113
13 Organisation of 'Prediction module'	115
14 Organisation of 'Consultation module'	116
15 Organisation of 'EMP module'	118
16 Organisation of 'Interfacing module'	119
17 Organisation of 'Help module'	121
18 An example of graphical user interface in EMP-Ex	125
19 Structure and elements of a rule	126
20 An example of forward chaining technique in EMP-Ex	127
21 Loading EMP-Ex file by wxCLIPS	131
22 Selecting 'Start Application' submenu of wxCLIPS to call the first screen of EMP-Ex	131



<b>Figure</b>		<b>Page</b>
23	An example screen showing a function of 'File' menu to load a text file on text window	133
24	An example of screen operating 'Introduction' menu	134
25	A screen displaying declarative knowledge and some path ways of decision making process in EIA procedure	135
26	Flowchart of EIA menu	136
27	Flowchart of soil erosion prediction	142
28	An example screen displaying series of questions in soil erosion prediction	143
29	Screen continuing to show the process of soil erosion prediction	143
30	Meta rules and procedural rules in soil erosion prediction	144
31	Examples of wxCLIPS syntax developed in EMP-Ex for soil erosion prediction	145
32	Flowchart of runoff prediction for projects located in urban areas	149
33	Screen showing the process of predicting runoff in urban areas	150
34	Screen continuing to show runoff prediction and recommendation	150
35	Example of rules involved in runoff prediction for projects located in urban areas	151
36	Flowchart of runoff prediction for projects located in rural areas	154
37	Screen showing steps to predict peak runoff in rural areas	155
38	Another screen showing steps to predict peak runoff in rural areas	155
39	An example of recorded input and output	157
40	Suggestion for mitigation measure for erosion control using fibromatting and hydroseeding	157
41	Flowchart of the consultation menu	158
42	An example of input and output of EMP-Ex consultation	160

<b>Figure</b>	<b>Page</b>
43 A screen displaying a function of consultation module to guide users in monitoring the effectiveness of silt fence	160
44 A knowledge base for determining of effective length and remaining depth of silt fence	162
45 A screen recommending the level of BOD of wastewater discharged from project activities	163
46 Screen showing how EMP-Ex guides users to prepare an EMP	165
47 Some examples of rules used to guide users in preparing an EMP	166
48 A screen showing an example of EMP developed by EMP-Ex	167
49 Content of EMP report, supporting files and size	168
50 EMP-Ex interfacing with IDRISI to display a landuse map	170
51 EMP-Ex interfacing with AutoCAD R14 to display a contour map	170
52 An example of help menu showing system explanation facility	171
53 Flowchart showing the processes of testing EMP-Ex	173
54 A screen showing a function of tracing feature, a debugging utility provided in wxCLIPS shell to show a syntax error of programming during EMP-Ex construction	175
55 An error in loading a supporting file which has '.bmp' extension	176
56 A screen showing a function of wxCLIPS consistency checker used in EMP-Ex to flag users for a wrong data entry	177
57 A screen showing EMP-Ex installation	186
58 Screen showing the way to start EMP-Ex via the start menu	186
59 Location of study area for field testing of EMP-Ex from CH 22+000 to CH 23+500	201
60 Location of study area for field testing of EMP-Ex from CH 23+500 to CH 25+000	202
61 Rule documentation form	207
62 An example screen of user guide in EMP-Ex	213

## **LIST OF ABBREVIATIONS**

AI	Artificial Intelligence
ANSI	American National Standards Institute
CLIPS	C Language Integrated Production System
COOL	CLIPS Object Oriented Language
DBMS	Data Base Management System
DID	Department of Drainage and Irrigation
DOE	Department of Environment
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMP-Ex	Environmental Management Plan Expert System
EMS	Environmental Management System
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
GIS	Geographic Information System
GUI	Graphical User Interface
MARDI	Malaysia Agricultural Research Development Institute
NASA	National Aeronautics and Space Administration
RAM	Random Access Memory
VGA	Video Graphic Accelerator

## CHAPTER I

### INTRODUCTION

It is now generally accepted that economic development strategies must be compatible with environmental goals. This requires the incorporation of environmental dimensions into the process of development. It is important to make choices and decisions that will eventually promote sound development by understanding the environment functions. During the construction phase of development projects, the removals of vegetation cover together with earthwork activities reduce the stability and bonding of soil. Without the protection and binding properties of vegetation, there will be serious problems of soil erosion and water resource deterioration.

In response to this threat, it is recognised that environmental consideration should be fully taken into account at the earliest project planning stage. Thus, Environmental Impact Assessment (EIA) which involves the integration of environmental factors into development planning is now recognised as a tool in environmental management (FAO, 1995). An objective of EIA is to develop Environmental Management Plan (EMP) for ensuring that the proposed development activities are undertaken with due consideration to the conservation of the ecosystem and sustainable development.

In environmental management planning for development projects, soil and water conservation, erosion and sediment control, and environmental monitoring programme are considered very important parts of EMP. With the recently

introduced ISO 14000 series on Environmental Management System (EMS), there are provisions for the design of an EMP that includes provisions for the management of soil and water during site clearing and earthworks (DOE, 1996). However in Malaysia, the EMP has just been developed as a part of environmental assessment in late 1995; therefore, the concept of environmental management planning is relatively new in the Malaysian context and information is very sparse.

### **Statement of the Problem**

Some of the main problems in applying EMP procedure in Malaysia are:

1. It is costly to engage the required team of specialists competent enough to examine in detail the diverse topics encountered in an EMP.
2. Failure to propose environmental monitoring which is a part of the EMP or failure to propose Emergency Response Plan (ERP).
3. The existing EMPs attached in EIA reports are not consistent. There are various formats and practical details are not enough, especially in soil and water conservation that is very important in environmental management planning.

Furthermore, it cannot be denied that the period required by project proponents, environmental consultants, to prepare high quality plans and authorised agencies to review the plans can be shortened. Moreover, budget can be saved if

there is an appropriate technology for helping these working groups (We Lin and Noor, 1995). Therefore, the idea of developing an expert system computer programme, which could assist in solving these problems, has been suggested. Furthermore, the expert system is efficient and fast in continuous updating and extracting large databases to be applied appropriately.

### **Research Objectives**

The specific objectives of this study were:

1. To check the existing information of EMP and related information from the Department of Environment;
2. To extract and encode knowledge from domain experts together with knowledge from established literature on main problems related to environmental management planning in soil and water conservation for developing rule-bases of an expert system;
3. To provide practical knowledge bases regarding problems of soil and water conservation during earthwork activities of development projects; and
4. To develop a comprehensive expert system that can be used as a device for preparing environmental management plan with regard to soil and water conservation.

### **Scope and Limitations**

Only the design and operational aspects for soil and water conservation in environmental management plan (EMP) were considered in this study. The other components of the EMP, such as planning for air and noise quality, forestry and wildlife, and other social factors were not taken into account.

### **Expected Outcome of the Study**

The expected outcome of this study is an expert system prototype called “**Environmental Management Plan Expert System (EMP-Ex)**” that will be useful to prepare high quality EMP reports, especially in the situation of insufficient human experts. The expert system developed will also assist authorised agencies such as the Department of Environment (DOE) in auditing and revising the plans. Furthermore, it has significant potentials for use in environmental training and education, particularly when there is shortage of expertise as in the field of environmental assessment.



## **CHAPTER II**

### **LITERATURE REVIEW**

Economic, social and environmental change is inherent to development. Whilst development aims to bring about positive changes, it can lead to conflicts. In the past, the promotion of economic growth as the motor of increased well-being was the main development thrust with little sensitivity to adverse social or environmental impacts. The need to avoid adverse impacts and to ensure long-term benefits led to the concept of sustainability. This has become accepted as an essential feature of development if the aim of increased well-being and greater equity in fulfilling basic needs is to be met for this and future generations. In order to predict environmental impacts of any development activity and to provide an opportunity to mitigate against negative impacts and enhance positive impacts, the environmental impact assessment (EIA) procedure was developed in 1970s.

#### **Environmental Impact Assessment**

Environmental impact assessment (EIA) can be defined as the process that identifies, predicts, evaluates, and communicates information concerning the adverse and beneficial impacts of proposed projects, plans, programmes, or legislative actions relative to the physical, chemical, biological, cultural, and socio-economic components of the total environment (DOE, 1995b; Canter, 1996). The EIA also specifies any mitigation measures that are required to alleviate significant environmental impacts, prior to project approval and implementation (FAO, 1995). It is important to understand where EIA fits into the overall scheme of environmental management. Pollution control is essentially a curative process